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Results of Observations of the Leonid Meteors of 1899 *as seen from the Royal Observatory, Edinburgh.* By George Clark, M.A.

(*Communicated by the Astronomer Royal for Scotland.*)

The sky in the neighbourhood of *Leo* was carefully watched during the whole of the night of Tuesday, November 14, and Wednesday, November 15, from 10.30 P.M. till 6.30 A.M. on each occasion. On both nights the sky was perfectly cloudless, but the fact that the gibbous Moon was riding high in the heavens made it difficult to observe the fainter meteors, and proved a serious drawback to photographic work.

The first *Leonid* on Tuesday was seen at $11^h\ 45^m$, and from then on till 16^h they occurred at long intervals, sometimes even half an hour elapsing without a single meteor being observed. As each appeared its apparent path was marked as accurately as possible on previously prepared maps. After 16^h it became evident that the shower was increasing, and the meteors gradually occurred more frequently till 17^h, when for a short time they appeared at average intervals of perhaps one minute.

Throughout the whole night the great majority of the paths radiated from the vicinity of the Sickle towards the southern half of a circle described round the radiant, very few meteors being observed to travel in a northerly direction. There was no difficulty whatever in discriminating between the *Leonids* and other meteors of a more sporadic nature which from time to time flashed across the sky. The radiant character of the former was very evident, and is distinctly brought out by the paths as drawn on the maps. Moreover, the *Leonids* shot forth with great swiftness, and were of an intense bluish-white colour, bearing indeed a marked resemblance to certain kinds of rockets. They had the same sort of bright bulb at the head, and left similar trails, some of which, even in the bright moonlight, persisted for several seconds. Some of these trails were very long, indicating that the meteors had passed "broad on" to the observer; while others were much foreshortened, owing to perspective. It was noticeable that these very short paths were almost all entirely within the bounds of the Sickle. The meteors seen between 17^h and $17^h\ 30^m$ seemed to be the most brilliant of the display; but as the Moon set at $17^h\ 19^m$ this was doubtless largely due to the consequent greater darkness of the sky. It did not occur to any of us that what we saw at this time could possibly represent the main stream of meteors, and hopes were confidently entertained that the grandest part of the display was still to come.

On Wednesday night, however, there was a considerable amount of haze; and at 14^h a damp, heavy fog came on, which lasted for about an hour. Owing to these circumstances it is more than likely that faint meteors entirely escaped observation;

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indeed, during the whole watch of seven hours only two meteors of any description were seen, neither of them being a *Leonid.*

Arrangements were made by Mr. Heath for photographing the meteors by mounting two cameras—one of them for plates 18″ by 16″—on the 24-inch reflecting telescope. Between 17^h and 18^h on Tuesday, while the display was at its best, two plates were exposed; but unfortunately the attempt was not attended with any success.

Two charts were used on which to draw the apparent paths of the meteors observed. The first contains thirty-two meteors, and was in use on Tuesday night from 11^h till $16^h\ 30^m$; while the second contains forty-two meteors observed on the same night between $16^h\ 30^m$ and $18^h\ 45^m$. For the directions of several paths on each map I am indebted to Dr. Halm.

The method adopted in determining the apparent radiant point and the results obtained are briefly as follow :—

In the first place the arrows on each map were taken in pairs, such that the components of each pair were as nearly as possible at right angles to one another, no single arrow being made use of more than once. In this way twelve pairs were obtained on the first map and fourteen on the second. The exact position of the intersection of each pair was then determined, with the results exhibited in Table I.

TABLE I.

Map I.		Map II.	
R.A.	Decl.	R.A.	Decl.
h	°	h	°
10·10	+24·0	9·92	+22·7
10·06	22·0	9·88	22·5
9·88	23·9	10·02	21·2
10·04	23·2	9·98	22·9
9·93	23·6	9·97	21·9
10·06	23·4	9·97	21·9
9·98	22·8	10·02	23·4
9·86	21·5	10·08	23·1
9·90	23·4	9·97	23·2
10·01	22·8	9·98	24·1
9·90	22·0	10·00	23·2
10·05	24·0	9·82	22·5
		9·96	22·0
		9·98	22·2

The mean of the results in Map I. is—

$$\text{R.A. } 9^h\ 58^m{\cdot}8 \pm 1^m{\cdot}4\ ;\ \text{Decl. } +23^\circ\ 3' \pm 15'{\cdot}3$$

and in Map II.—

$$\text{R.A. } 9^h\ 57^m{\cdot}6 \pm 1^m{\cdot}0\ ;\ \text{Decl. } +22^\circ\ 37'{\cdot}2 \pm 12'{\cdot}4\ ;$$

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while the mean of the results of both maps taken together is

$$\text{R.A. } 9^{h}\ 58^{m}{\cdot}2 \pm 0^{m}{\cdot}8\ ;\ \text{Decl. } +22^{\circ}\ 48'{\cdot}0 \pm 9'{\cdot}5.$$

To compute the amount of the zenith attraction, and the *true* position of the radiant point, it was necessary first to determine the zenith distance (Z) of the *apparent* radiant. This was computed (1) for the hour angle of the apparent radiant corresponding to the mean of the times (viz. $15^{h}\ 0^{m}$) at which the observations on the first map were made, and (2) for the similar hour angle at the mean of the times (viz. $17^{h}\ 37^{m}$) recorded on the second map. The amount of the zenith attraction was then obtained from Schiaparelli's formula

$$\tan \tfrac{1}{2}\,\phi = \frac{w-\omega}{w+\omega}\,\tan \tfrac{1}{2}\,Z,$$

where ϕ=zenith attraction ; w=accelerated velocity of meteors due to Earth's attraction ; ω=orbital velocity of meteors ; and Z=apparent zenith distance of radiant.

Finally, to determine the corrections to the R.A. and Decl. of the apparent radiant, we have

$$d\alpha = \phi \sin \eta \sec \delta\ ;\ d\delta = -\phi \cos \eta,$$

η being the parallactic angle.

The results thus deduced are arranged in order in the following table (II.) :—

TABLE II.

Map.	Z.	ϕ	$d\alpha$.	$d\delta$.	Corrected Position of Apparent Radiant. R.A.	Corrected Position of Apparent Radiant. Decl.	Weight.
	° ′	′	m	′	h m	° ′	
I.	49 25·8	20·2	+0·8	−16·6	9 59·0	+22 31·4	1
II.	34 8·5	13·5	+0·2	−13·2	9 58·4	+22 34·8	1·16

By combining the R.A.'s and declinations given in the last two columns according to their weights, the mean position of the *true* radiant point was found to be

R.A. $9^{h}\ 58^{m}{\cdot}6$; Decl. $+22^{\circ}\ 33'{\cdot}2$ (equinox of 1900·0).

Assuming this position for 1899 November, 14·73 G.M.T., the elements of the orbit have been computed for the period 33·25 years. But, as remarked by Dr. Rambaut in his paper reprinted from the *Proceedings of the Royal Society*, vol. lxv., there appears to be reason for believing that the most probable value of the period of revolution is at present about 33·49 years. The elements have therefore also been computed for this period, and the two sets of results are given in the first two columns of Table III. subjoined. For the sake of reference Dr. Rambaut's results for 1898 are given in column 3. Column 4 contains the elements for 1866 as established by the late Professor Adams, and column 5 the elements of the orbit of Comet I., 1866 (Temple's)

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as computed by Dr. von Oppolzer. In each of these last two cases the elements have been brought up to the epoch 1900·0.

TABLE III.

		1 Edinburgh, 1899.	2	3 Rambaut, 1898.	4 Adams, 1866.	5 Comet I., 1866.
Period	P	33·25 yrs.	33·49 yrs.	33·49 yrs.	33·25 yrs.	33·17582
Mean Distance	a	10·34	10·39	10·39	10·34	10·3247
Angle of Eccentricity	ϕ	64°45′·0	64°48′·7	64°50′·0	64°47′·0	64°52′·8
Inclination	i	16°31′·3	16°31′·2	16°3′·0	16°45′·87	17°17′·95
Longitude of ☊	☊	52°39′·7	52°39′·7	53°2′·0	51°54′·97	51°53′·75
Longitude of Perihelion	π	56° 1′·7	56° 4′·2	58°40′·0	58°45′·17	42°52′·5
Perihelion Dist.	q	0·98789	0·98794	...	0·9885	0·97652
Time of Perihelion Passage	T	Nov. 12^{d}·257	Nov. 12^{d}·251	...	...	Jan. 11·13388

Royal Observatory, Blackford Hill, Edinburgh :
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Erratum in Monthly Notices, vol. lx. page 18 (last line).

For 9^{m} to ·49^{m}·2, *read* 9^{m}·4 to 9^{m}·2.